THURSDAY, AUGUST 6, 1908.

THE WORK OF J. S. BUDGETT.

The Work of John Samuel Budgett, Balfour Student of the University of Cambridge. Being a Collection of his Zoological Papers, together with a Biographical Sketch by A. E. Shipley, F.R.S., and Contributions by Richard Assheton, Edward J. Bles, Edward T. Browne, J. Herbert Budgett, and J. Graham Kerr. Edited by J. Graham Kerr. Pp. x+494; 28 plates, 173 figures. (Cambridge: University Press, 1907.) Price 25*s.* net.

THIS stately volume is an appropriate tribute to the memory of Mr. J. S. Budgett, whose untimely death in 1904 was a sad loss to zoology. He was always one who loved hard work, and it is fitting that the memorial which his friends have raised as an expression of their esteem should consist of a reprint of his papers and of a working out of the valuable material which cost him his life. Budgett was a zoologist of the best type, combining the enthusiasm of the field-naturalist with the austerity of the morphologist, and "the patient persistence of his quest for the eggs of Polypterus under crushing difficulties forms one of the most courageous episodes in the history of zoology." "After years of patience, after three unsuccessful journeys into the heart of Africa, he at last succeeded where all others had failed." He had the joy of watching the development of this remarkable type, but it was for others to enter into his labours. He succumbed to malaria and blackwater fever a few days after he had finished his drawings of the external features of the developing ova. It seems a terrible price to pay for another chapter of embryology, yet Mr. Shipley reminds us in his sympathetic biographical sketch of a remark made by Robert Louis Stevenson, that "to be wholly devoted to some intellectual exercise is to have succeeded in life."

The book begins with the biographical sketch—good reading for all, for those in particular who are not too old to learn. Then follow the reprints of Mr. Budgett's zoological papers (1899–1903) on Polypterus and Protopterus, on the habits of other West African fishes, on Phyllomedusa and other Paraguayan batrachians, on the ornithology of the Gambia River, &c. His work was characterised by "an almost fastidious degree of accuracy," and is of enduring quality. "We owe to him the first accurate account of the urino-genital organs of Polypterus, and the demonstration that the crossopterygian fin is really a uniserial archipterygium; besides a series of invaluable observations upon the life-history and breeding habits of many tropical frogs and fishes."

In spite of Budgett's work, there is still lack of definite observations regarding the oviposition and fertilisation in Polypterus; it seems that the eggs are deposited in the shallow lagoons connected with the main river early in the rainy season; they apparently adhere strongly to submerged twigs or water-plants. There are certain peculiarities—such as the modified and erectile character of the anal fin of the male—which point to internal fertilisation, and in this connection we may refer to an interesting letter (p. 291) from Mr. J. Herbert Budgett on the supposed courtship. The young fry apparently accompany the parent (probably the male) in a dense swarm, very much as is the case in actinopterygian bony ganoids.

Prof. Graham Kerr has used to good purpose Mr. Budgett's collection of the eggs and embryos of *Polypterus senegalus,* and has worked out, what has been for so long a desideratum, a fairly complete picture of the general course of development in a crossopterygian fish. The memoir is a noteworthy example of careful and skilful morphological work. We cannot do more than refer to some of the interesting results.

The segmentation is complete, and in its earliest stages nearly equal; the invagination groove is at first nearly equatorial in position; as the curve described by the groove becomes closed an enormous "yolk plug" is formed; rudiments of external gills and cement organs appear at an early stage; the buccal cavity is for a while a widely-open space bounded by the cement organs, the lower side of the head and the cardiac region. The mesoderm of the trunk region arises as it does in Lepidosiren, Protopterus, and Petromyzon, by "delamination." A well-developed solid post-anal gut is present which eventually breaks up and disappears. The secretory epithelium of the cement organ is endodermic, arising as a pair of hollow enteric diverticula, which become cut off from the rest of the endoderm and establish a connection with the outer surface. The lung rudiment is median and ventral, and very soon develops asymmetry. The pancreas arises from three rudiments, and the liver is really a hepatopancreas—the pancreatic tissue being spread out over part of its ventral surface. The dorsal aorta arises from cells or protoplasmic masses derived from the sclerotom; its lumen is derived from the fusion of originally separate vacuoles in these masses; the endocardium appears to be mesoblastic in origin; the blood corpuscles appear suddenly, and it is suggested that they are mesenchyme cells set free by an epidemic of mitosis. The chondrocranium is amphibian-like in early stages.

The neural tube arises by overarching of the medullary folds; both infundibulum and optic rudiments are clearly recognisable while the medullary groove is still widely open throughout; as in Lepidosiren, &c., the brain is, during the earlier part of its development, subdivided into two—not three—regions, the primitive forebrain and the rhombencephalon; the pineal outgrowth is single, and without any eye-like structure; in the adult the cerebellum becomes highly developed and forms anteriorly a valvula cerebelli, while posteriorly it projects back in a quite similar manner into the fourth ventricle; the material forming the side walls of the thalamencephalon does not become pushed out to form cerebral hemispheres, but is accommodated partly by the great increase in length of the thalamencephalon, partly by its becoming invaginated into the interior of the third ventricle; the two olfactory rudiments are apparently connected by an ectodermal thickening across the middle line in early stages; the cavity of the olfactory organ is a secondary excavation in the originally solid rudiment.

Prof. Kerr does not enter into any elaborate discussion of the general import of the results reached, but some very interesting, more or less speculative, conclusions are suggested:—

(1) "On the whole the general phenomena of

development in Polypterus show frequent striking resemblances with what occur in Dipnoans and in the lower Amphibia. I believe these resemblances are sufficient by themselves to indicate the probability that the Teleostomes, the Dipnoans and the Amphibians have arisen in phylogeny from a common stem, which would in turn probably have diverged from the ancestral Selachian stock. The ancestors of the Amniota probably diverged either about one or about several points from the region of the stem common to Dipnoi and Amphibia."

(2) The external gills develop in Polypterus exactly as they do in Lepidosiren and Protopterus and in the more primitive Amphibia (Urodela and Gymnophiona), *i.e.* each one arises as an outgrowth from the outer side of the visceral arch (in this case hyoidean), composed of mesenchymatous core with ectodermal covering. They appear before the perforation of the gill-clefts, and are probably organs of great antiquity. The respiratory epithelium of the gill-clefts has arisen by a spreading inwards from the ectodermal respiratory epithelium of the external gills.

(3) It may be that paired limbs are homodynamous with external gills in which the potential motor function has been accentuated.

(4) As Budgett showed, the condition of the fin-skeleton in the 30 mm. larva of Polypterus indicates its close relationship to the type of uniserial fin-skeleton occurring in sharks. Prof. Graham Kerr briefly re-states the hypothesis that both can be referred back to a primitive biserial archipterygium like that of Ceratodus.

(5) In the evolution of the head there has been a varying amount of displacement in an anteroposterior direction of the relative positions of mesoderm segments and visceral pouches, and it is suggested that the enterocœlic pouches were once wholly posterior to the visceral pouches, and that the two structures are really homodynamous.

(6) The nervous material which corresponds with the whole of the cerebral hemisphere in the higher forms—including the pallium or mantle—lies in Polypterus in the thickened wall of the thalamencephalon. What is ordinarily called the pallium in a crossopterygian is simply the roof of the thalamencephalon, and the conditions in actinopterygian ganoids and teleosts are similar.

In the river Gambia Mr. Budgett found the "nest" of *Gymnarchus niloticus,* a primitive and at the same time specialised teleostean, belonging to the family Mormyridæ. He secured a fine series of the eggs at different stages, and these have been described by Mr. Richard Assheton in a remarkably fine memoir, which is the first contribution to the embryology of Mormyrids. Mr. Budgett gave an account of the floating nest with its thousand large eggs like amber-beads. The development is extraordinarily rapid, for the eggs hatched in seven days, and in eighteen days the young fry left the nest three inches long. Mr. Budgett thought that the development was "exceedingly shark-like," but this has not been borne out by Mr. Assheton's work. There is a large mass of yolk, and the larvæ have very long gill-filaments hanging down in two blood-red branches, but the development is on the whole typically teleostean. We can only refer to a few of the many interesting features.

The alimentary canal arises as a cleft among the hypoblast cells. At an early stage—or perhaps from the beginning—the whole of the pharyngeal region is without a lumen, and it does not get one until after hatching. There is one pair of true gill-clefts between the sixth and seventh visceral arches; the other "gill-clefts" of embryonic life are invaginations of the ectoderm which undermine the visceral arches. There are long external uniramous gill-filaments upon the first, second, third, and fourth branchial arches, which shrivel after the operculum has grown over them, excepting the proximal ends which give rise to the permanent gills. The whole apparatus is lined by epiblast from first to last.

The air-bladder, which arises as a single diverticulum of the œsophagus a little to the left of the mid-dorsal line, has right and left lobes, and is extremely lung-like. Its structure, its vascular supply, and the habits of the fish all point to its use as a lung. The yolk-sac is to be regarded as an appendage of the liver—due to the accumulation of yolk in that part of the egg which normally becomes the liver. The gall-bladder and liver arise by the constriction off of a large ventral recess of the alimentary canal (just posterior to the œsophagus); the pancreas is developed as diverticula of the bile-ducts (the constricted region just mentioned), and these grow backwards to mingle with the "islands of Langerhans" tissue and even with the spleen; the islands of Langerhans arise very early as a solid mass of epithelial tissue which becomes broken up by the splitting of the mesenteric artery.

There are certain features which suggest an earlier condition of teleostean evolution than is the case with other members of the class the development of which has been studied hitherto, and Mr. Assheton inquires whether Teleosteans may not be descended from a proto-amphibian race. He refers to the amphibian-like character of the lips of the blastopore, to the vestige of neural tube formation, to various features in the development of the excretory system, to the lung-like and vestigially double air-bladder, to the trace of an auricular septum and the suggestion of a double circulation, to the large size of the aortic arch of the fourth visceral arch, and to the peculiar character of the gill-clefts, filaments, and arches.

Is it possible that the teleosteans descended from a proto-amphibian stock more amphibian than the Dipnoi, that they owe their position of prestige to having served an apprenticeship in a less regular and constant environment, that a mutation led to a return to strictly aquatic habits? With questions such as these, Mr. Assheton relieves his statement of the facts of the development of Gymnarchus.

Mr. Assheton also reports on sundry teleostean eggs and larvæ which Mr. Budgett collected in the Gambia, and Dr. E. J. Bles contributes descriptions of some stages in the development of three Anura—*Paludicola fuscomaculata, Hemisus marmoratum,* and *Phyllomedusa hypochondrialis.* The last paper reminds us of what will strike everyone who looks over this stately volume; we refer to the fine illustrations. Mr. Budgett was a skilful draughtsman, Mr. Assheton is equally gifted, and there is quite remarkable merit in the drawings by Mr. A. K. Maxwell.

One of Mr. Budgett's discoveries was a fresh-water medusa in the delta of the Niger. According to Mr. E. T. Browne this is referable to the species (*Limnocnida tanganicae*) that has been found in Lake Tanganyika, and its occurrence in these widely-separated localities becomes intelligible if we regard it as a relic of the fauna of the Lutetian Sea, which the geologists believe to have stretched across Africa in Middle Eocene times. Mr. Browne gives an interesting account of this remarkable type, which remains unclassifiable. There is probably a gymnoblastic hydroid stage awaiting discovery.

The volume is an eloquent tribute to the esteem in which Mr. Budgett was held by his friends, for besides the editorial labours and Mr. Shipley's beautifully executed sketch, the working-up of the embryological material—especially that which fell to Prof. Graham Kerr and Mr. Assheton—must have involved much time and thought. Those who have by their own masterly work thus completed Budgett's have certainly been generous in their friendship, and the memorial volume, which is a valuable contribution to embryology, will surely not fail of its highest purpose, of perpetuating by its stimulus the tradition which Budgett's life and work expressed.

HIGHER ALGEBRA AT HARVARD UNIVERSITY.

Introduction to Higher Algebra. By Maxime Bôcher. Prepared for publication with the cooperation of E. P. R. Duval. Pp. xi+321. (New York: The Macmillan Co.; London: Macmillan and Co., Ltd., 1907.) Price 8*s.* net.

WITH the cooperation of a former pupil, Mr. E. P. R. Duval, Prof. Bôcher has made into a book part of the subject of his lectures during the last ten years. Of course, it would be unfair to try to reconstruct the lectures from the book, but we do get an impression from this volume, and especially from the preface, of the problems which a Harvard professor has to face, and how he deals with them. We are told that

> "An American student approaching the higher parts of mathematics usually finds himself unfamiliar with most of the main facts of algebra, to say nothing of their proofs. Thus he has only a rudimentary knowledge of systems of linear equations, and he knows next to nothing about the subject of quadratic forms."

For a student of this kind Prof. Bôcher provides a book which contains the elementary theory of polynomials, determinants, systems of linear equations, matrices, invariants, and symmetric functions, besides a discussion of quadratic forms which goes into considerable detail, and is based on the work of Smith, Sylvester, Weierstrass, and Kronecker.

The author makes special mention of Kronecker and Frobenius, and, in fact, it is easy to see how these great analysts have influenced the writer both in his choice of topics and mode of treatment. Whatever may be thought about the subjects discussed, there is no doubt about the soundness and thoroughness of the treatment; and it would be very interesting to know what is the effect of a course of this kind upon a class of American students, and what would be the result of giving it to an English class of a similar grade. It ought at least to arouse interest, and would probably induce the best students to read some first-rate memoirs, and possibly produce something of their own—though it must be confessed that the theory of quadratic forms, which is the *terminus ad quem* of this book, has been so thoroughly worked out now that there does not seem much chance of developing it further.

It should be stated that Prof. Bôcher by no means confines himself to abstract analysis; on the contrary, like Klein, he takes every opportunity of giving geometrical interpretations, and although he does not say so, it is likely enough that he has illustrated by diagrams and models the different ways in which two proper or degenerate quadric surfaces may intersect. Some of his groups of examples are calculated to suggest methodical lines of research in other directions; for example, on pp. 260–61 we have an outline of the theory of the binary quartic.

Generally speaking, the style of the book is very clear and simple. One exception occurs on p. 120, theorem 2, where it is not sufficiently emphasised that in the first case $\Sigma a_{ij}x_iy_j=0$ is to be made an identity in the x's by giving suitable fixed values to the y's. And although the notion of a domain of rationality is explained (pp. 175, 212, 216), it would have been better to do this at an earlier stage.

The printing, done at the Norwood Press, is very good on the whole, but the suffixes are often unpleasant to look at, owing to want of gradation in type. On the other hand, we do find $x_2''^2$ printed nearly as it is written—a very rare experience in English-printed books. It would serve a useful purpose if a congress could be held between mathematicians and mathematical printers and compositors; the former often forget that what is easy to write may be difficult to print, and the latter are very conservative, besides failing to sympathise with a mathematician's way of writing formulæ, especially in matters of proportion and spacing.

G. B. M.

METEOROLOGICAL OBSERVATIONS.

The Observer's Handbook, Meteorological Office, 1908. A new and revised edition of Dr. R. H. Scott's "Instructions in the use of Meteorological Instruments." (London: H.M. Stationery Office.)

THIS book consists of two parts, and appendices. Part i. follows somewhat in the line of Dr. Scott's handbook, but part ii. is practically new, and deals with recording instruments, several of which have come into use since the previous book was published.

The issuing of a new official guide for its observers by the Meteorological Office gives an opportunity of comparing the state of the science of meteorology now and twenty years ago, in so far as instruments and